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ASSESSMENT OF FATIGUE OF RAILWAY BRIDGE

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Abstract: *The aim of this paper is to investigate the change of stiffness of concrete railway bridge subjected to cyclic loading since cyclic loading affects several types of concrete structures during their service life. Its greatest impact can be seen on bridges, which are subjected to enormous loads from passenger of freight traffic in terms of weight as well as frequency. A railway bridge was chosen for application in order to simplify the task, as the trains are represented by uniformly distributed load at a specific location defined by the track. In this analysis, only the changes in concrete were considered. The reduced stiffness values were placed in to the calculation model following the standard staggered algorithm scheme. This application provided a base for drawing conclusions regarding the used cross-section of the bridge deck.*

Keywords: ***Cyclic loading, dynamic analysis, fatigue of concrete, stiffness of structures.***

1. Introduction

The civil engineering structures suffer from enormous static and cyclic loads and dynamics effects. For investigation of the effect of cyclic loading, the best example is a railway bridge. This structure has to sustain millions of loading cycles. With proper observation and scanning of the bridge, Fig. 1, it is possible to recognize and study the fatigue development.

Fig. 1: Örnsköldsvik Bridge (Elfgren et. al., 2007)

2. Analysis of bridge

The results of the analysis showed that the bridge cross section is very stiff even in extreme conditions when only fatigue of concrete is considered and that the fatigue of concrete does not influence the structure so much since the stresses on the structure are small. It is due to type of the cross section of the bridge. It is shown in Tab. 1 that the structure will not collapse from fatigue of concrete.

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Tab. 1: Decrease of modulus of elasticity.

Cyclic loading (year)	E_c (MPa)
1	32.70
25	32.67
50	32.66
75	32.66
100	32.66
200	32.65
300	32.65
400	32.64
500	32.64
600	32.64
700	32.64
800	32.64
900	32.64
1000	32.63

A method for evaluation of stiffness decrease of concrete railway bridges due to cyclic loading was developed. The method combines the concept of the fatigue damage function and the commonly available finite element tools for structural dynamics analyses. The computation method represents a staggered algorithm when the actual stiffness of concrete at a given point is updated after a sufficiently small number of load cycles. Then the updated stiffness is used for the dynamic analysis at the following time step. It is believed that the proposed method can help to assess the residual service life of existing concrete structures subjected to cyclic loading or it can support design of new concrete structures and improve their long-term resistance to fatigue effects of concrete.

To prove the applicability of the proposed method, it was applied to an existing reinforced concrete railway bridge, which in turn helped the author to understand some of the dynamic aspects of bridge engineering. The data used in this application were taken from the relevant design documentation and from literature. The tested bridge responded to the cyclic loading by gradual redistribution of the bending moments and deflections. However, the magnitude of the tensile and compressive stresses remained almost constant during the entire tested period, even though an extreme load scenario in terms of the frequency of heavy trains was considered. Therefore, based on the obtained result, it can be concluded that the relatively stiffer bridges with U-shaped cross section decks do not tend to fail due to poor fatigue performance. Then, the actual failure is likely to happen due to exposure to weather and chemicals, which may accelerate the process of loss of stiffness.

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